Brand Experience and Package Size in Dynamic Consumer Choice

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Abstract

Consumers choose which brand and how much to buy. Using cough-drop market data, where infrequent purchases allow clean observation of consumption spells, we document that purchase size increases with within-spell brand experience and decreases following brand switching. We explain these patterns with a model of brand and quantity choice under learning about quality. As experience accumulates, declining uncertainty and selection into preferred brands increase purchase size, while brand switching renews uncertainty and induces smaller trial purchases. These patterns are consistent with learning rather than switching costs alone. Purchase quantities provide a novel behavior margin for understanding consumer behavior.

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1. Introduction

A packaged-goods purchase involves two closely related decisions: which brand to buy and how much of it. In practice consumers make them together, yet the literature has largely studied them apart. One body of work treats package size as a problem of inventory management, stockpiling incentives, pricing, and consumption needs (Krishnamurthi and Raj 1988; Tellis 1988; Chintagunta 1993; Koenigsberg, Kohli and Montoya 2010; Yonezawa and Richards 2016). A separate body examines how prior experience shapes brand choice through learning, habit formation, and fixed costs of brand switching (Givon and Horsky 1979; Keane 1997; Seetharaman 2004; Dubé, Hitsch and Rossi 2010; Osborne 2011; Shin, Misra and Horsky 2012; Miravete and Palacios-Huerta 2014). The separation leaves a gap: if consumers learn about products through experience, that learning should affect not only whether they repurchase a brand but how much of it they buy.

The dynamic brand-choice literature is where this margin goes missing. It focuses on which brand consumers choose and how experience moves that choice, but routinely normalizes purchase quantity to one (Erdem and Keane 1996; Ching, Erdem and Keane 2013). As a result, a basic question has gone unasked: does brand experience change how much consumers buy? We show that it does, and that the size response is systematic enough to be a new observable in the study of dynamic consumer behavior.

We document two patterns and offer an explanation for them. Empirically, within a spell of repeated purchases of the same brand, purchase size grows with experience; across a brand switch, size growth falls. Intuitively, quantity tracks confidence: a consumer who has grown confident in a brand commits to larger quantities, whereas one trying an unfamiliar brand makes a smaller, cautious trial purchase. To formalize this intuition, we build a model of brand and quantity choice with learning about product quality, and we ask whether such a model can reproduce the size patterns we observe. Answering these questions first requires measuring experience cleanly from purchase data—a long-standing challenge, because observed histories rarely contain the initial conditions needed to it (Mehta, Rajiv and Srinivasan 2004; Shin, Misra and Horsky 2012; Ching, Erdem and Keane 2013).

The U.S. cough-drop market is well suited to meet this challenge. Cough-drop purchases follow a "burst-and-dormancy" cycle: short bursts of buying to treat an illness, separated by long dormant periods. These gaps provide a natural reset: 71% of households in our data experience at least one purchase gap exceeding a year. The reset gives plausibly exogenous variation for the learning process and mitigates the initial-conditions problem. We therefore measure experience within a purchase spell, from a clear starting point rather than an arbitrary point in a consumer's history. Furthermore, the same pattern implies little scope for stockpiling, so observed quantities closely track contemporaneous demand and become an informative margin for studying brand and size choice together.

Panel regressions with rich controls and fixed effects deliver two significant and robust findings. First, within a spell, additional experience with a brand raises purchase size growth. Second, brand switching lowers it. Both results replicate in margarine, indicating that the experience-size relationship is not specific to a single category (Dubé, Hitsch and Rossi 2009, 2010). To rationalize these patterns, we develop a dynamic model of brand choice that extends the standard Bayesian learning framework (Erdem and Keane 1996; Ching, Erdem and Keane 2013) with an endogenous purchase package-size decision and a fixed cost of brand switching. Because cough-drops account for a negligible share of consumers' budget, we adopt a quasi-linear utility specification.[1] The model generates size growth through two channels. First, resolving quality uncertainty lifts the quantity a risk-averse consumer is willing to buy. Second, selection on realized quality means consumers continue with a brand mainly when it proves good, so accumulated experience coincides with higher quality and larger sizes. The model rationalizes both empirical patterns, showing how experience moves brand and quantity choices together.

Our contribution is to bring purchase quantity into the study of dynamic brand choice. Quantity is a readable margin of consumer response to experience that the literature has set aside, and it offers firms a second dimension of their own transaction data—beyond the sequence of brands chosen—for reading how experience shapes demand. We are closest to Osborne (2011), who also identifies learning from observed purchases but through different variation: he compares newly introduced and established products within a forward-looking structural model, whereas we document how purchase quantity responds to within-consumer changes in experience. The approaches are complementary: variation across products versus variation in quantity within a consumer. Our infrequently purchased category gives a transparent treatment of initial conditions that supports reduced-form tests. Our analysis therefore contributes to the literature that separates learning from a pure switching-cost account of state dependence in consumer demand (e.g., Shin, Misra and Horsky 2012; Miravete and Palacios-Huerta 2014; Newberry 2016; Shcherbakov 2016).

The article proceeds as follows. Section 2 describes the data and the identification of spells. Section 3 presents the regression analysis and robustness checks. Section 4 develops the model, and Section 5 derives its implications and reports counterfactuals that favor learning over a pure brand switching-cost account. The final section concludes.

[1] This makes the quantity decision static conditional on the forward-looking brand choice, yielding sharp behavioral predictions that can be tested through reduced-form regressions on observed purchase sequences.

2. Cough-Drop Market Data

We use household-level scanner data from the Nielsen consumer panel for January 2006 through December 2015. Two national brands, Halls and Ricola, jointly hold about 65% of the cough-drop market. We model the choice among Halls, Ricola, and an outside good that aggregates all non-national brands. To study dynamic behavior, we restrict the sample to households with at least four cough-drop purchases.

Initial Conditions and Identifying Experience. The cough-drop category exhibits a distinctive burst-and-dormancy purchase pattern. Consumers typically make several purchases within a short period to treat an illness and then do not purchase again for an extended time. In our data, 71% of households experience at least one purchase gap exceeding one year.

This pattern provides a natural "reset" that addresses the initial conditions problem. As noted by Heckman (1981) and subsequent work (e.g., Simonov, Dubé, Hitsch and Rossi 2020), it is difficult to recover experience cleanly when the first observed purchase is correlated with unobserved consumer heterogeneity. We define a new purchase spell as beginning after at least one year without a cough-drop purchase. Such long periods of category inactivity naturally separate distinct illness episodes. Because cough-drops are inexpensive, low-involvement products that are purchased only episodically, cough-drops are unlikely to be stored for such a long period, and memories of previous purchase plausibly depreciate over that interval. The one-year gap therefore lets us measure experience from a common baseline rather than an arbitrary point in a consumer's history—a transparent and economically meaningful starting point for identifying the effects of experience. Our strategy ensures representativeness of the sample: Appendix Table A.1 shows that our sample households have characteristics similar to those in the full dataset.

The burst-and-dormancy pattern also suggests limited scope for stockpiling. Unlike many packaged goods, cough-drops are typically purchased for immediate use rather than stockpiled for future consumption.[2] Consequently, observed purchase quantities provide a close measure of contemporaneous demand, making the category particularly well suited for studying how experience affects brand and quantity choice.

Following Crawford and Shum (2005), we measure experience in terms of spells.

Definition 1 (Spell) *A spell is a sequence of consecutive purchases of the same brand.*

[2] Stockpiling is an important source of dynamic demand in many packaged-goods categories (Helsen and Schmittlein 1992; Hendel and Nevo 2006, 2013). Although inventory behavior affects purchase timing, it does not by itself generate persistence in brand choice. Moreover, inventory accumulation weakens the link between purchase quantities and contemporaneous demand.

Table 1: Descriptive Statistics: Household Purchase Behavior

	Panel A. Summary Statistics				
	Mean	S.D.	10p	50p	90p
Total number of purchases	9.24	9.07	4	6	17
Time (date) elapsed from the previous purchase	252.95	331.79	9	110	685
Number of spells per household	3.22	2.66	1	3	6
Spell length for all spells	2.87	4.03	1	2	6
Fraction of brand switching per household	0.26	0.23	0	0.25	0.57
Size choice (total counts in each shopping trip)	54.55	49.52	25	40	100
Size Growth (log difference between consecutive trips)	0.017	0.612	-0.693	0.000	0.788

		Panel B. Share and Switching Matrix		
		Halls	Ricola	Non-national brands
Share	at the 1st purchase	56%	7%	36%
	at the 4th purchase	56%	9%	35%
Switching rate	to Halls	78%	25%	27%
	to Ricola	4%	62%	3%
	to Non-national brands	18%	13%	69%

Notes: N=97,254 purchases from 10,506 households with at least four shopping trips. In Panel A, the Size Growth (log difference) is winsorized at the top and bottom 1% levels. In Panel B, the diagonal of the switching rate represents the conditional repurchase probability for each of the brands considered.

For example, the purchase history {Halls, Ricola, Ricola, Ricola} contains two spells: a length-one Halls spell followed by a length-three Ricola spell. By contrast, {Halls, Halls} is a single spell of length two, and {Halls, Ricola, Halls} is three spells of length one.

Throughout the paper, we measure experience within a purchase spell rather than over a consumer's cumulative history. Each brand switch begins a new spell, so experience accumulated under one brand does not carry over to another. Cumulative history, by contrast, pools distinct episodes across brands, making experience harder to interpret and more exposed to initial-condition problem and unobserved heterogeneity. Measuring within spells instead exploits within-consumer changes over time, the variation that identifies the experience effect.

Summary Statistics. Table 1 reports summary statistics. Panel B reveals substantial persistence in brand choice: the conditional repurchase probabilities are 78% for Halls and 62% for Ricola, both considerably higher than the corresponding market shares. This persistence, common in consumer-packaged goods, is the backdrop for our analysis: we focus on how experience and brand switching relate to purchase size.

The first two panels of Figure 1 show how brand switching varies with within-spell experience. Switching rates decline steadily as consumers gain experience: the probability

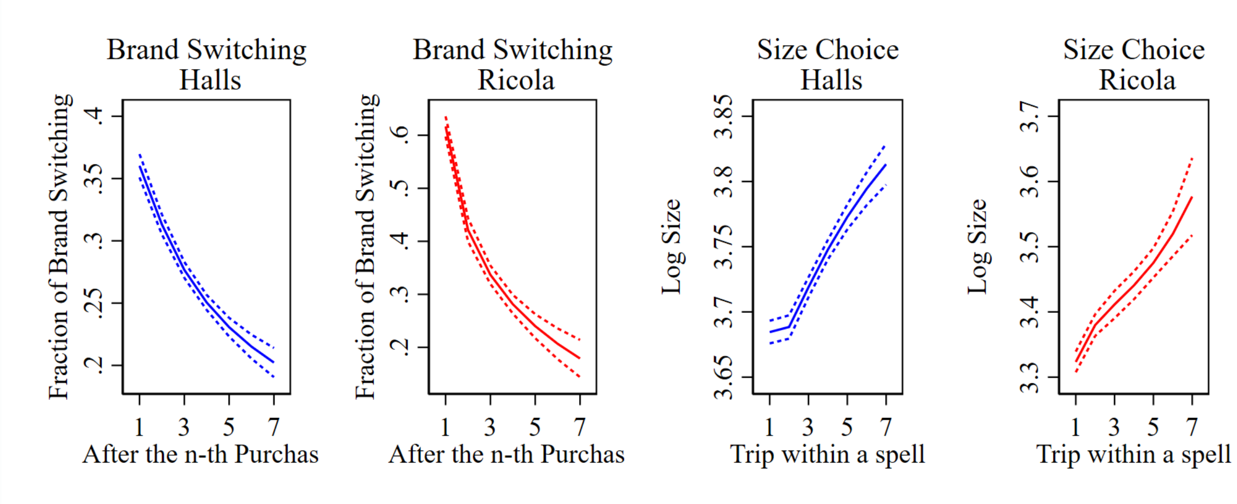

Figure 1: Fraction of Brand Switching and Size Choice over Experiences for Each Brand

Notes: The figures display the fractional-polynomial prediction plots (solid lines) with the 95% confidence intervals (dashed lines). The first and second panels plot the results of fraction of brand switching for Halls and Ricola. The third and fourth panels plot the results of size choice (counts) in log for Halls and Ricola.

of switching away is highest immediately after the first purchase and decreases thereafter. Switching from Halls, for instance, drops from 36% after the initial purchase to 23% for subsequent ones. This pattern is consistent with consumers initially exploring alternatives and later remaining with brands that better match their preferences.

More importantly, the last two panels of Figure 1 demonstrate that purchase size also increases systematically with within-spell experience for both brands. This size response has received little attention, yet it is exactly the margin our analysis brings into focus. The next section examines it using panel regressions.

3. Regression Analysis

3.1. Empirical Specification

The patterns in Figure 1 motivate two hypotheses about how experience and brand switching relate to purchase size.

Hypothesis 1 *Within a purchase spell, purchase size grows with experience.*

Hypothesis 2 *Purchase size growth falls with brand switching.*

To examine these hypotheses, we estimate a linear model relating purchase size growth to brand experience and switching:

$$\Delta\text{size}_{h,t} = \alpha\text{experience}_{h,t} + \beta\text{brand\_switching}_{h,t} + \mathbf{x}_{h,t}^{'}\theta + \delta_h + \gamma_{t_y} + \gamma_{t_m} + \epsilon_{h,t}, \tag{1}$$

where $\Delta\text{size}_{h,t} \equiv \ln\text{size}_{h,t} - \ln\text{size}_{h,t-1}$ is the growth (log-difference) of purchase size for household h on trip t.

Key Variables: Experience and Switching. *(i) Within-Spell Experience* ($\text{experience}_{h,t}$): We define experience by the within-spell number of previous purchase, i.e., the number of consecutive purchases of the currently chosen brand up to and excluding trip t. For a purchase sequence like {Halls, Ricola, Ricola, Halls}, the corresponding experience levels are {0, 0, 1, 0}. *(ii) Brand Switching* ($\text{brand\_switching}_{h,t}$): a dummy equal to 1 if the brand chosen at trip t is different from the brand at $t-1$, and 0 otherwise. Hence, Hypothesis 1 predicts $\alpha > 0$ (positive effect of experience), and Hypothesis 2 predicts $\beta < 0$ (negative effect of brand switching).

Because a switch forces zero within-spell experience, the switching and experience measures are perfectly collinear wherever a switch occurs, so both cannot enter the same regression. To address this, we adopt a two-step approach. First, we estimate the baseline model, equation (1), testing each hypothesis separately. Second, we develop a joint specification with categorical experience dummies that tests both hypotheses simultaneously.

A Joint Specification with Categorical Experience. To include both brand switching and experience in one regression, we partition within-spell experience, zero-indexed count of prior within-spell purchases, into four groups: the switch ($\text{brand\_switching}_{h,t} \equiv \mathbb{1}_{\{\text{experience}_{h,t}=0\}}$); low experience ($\text{low\_experience}_{h,t} \equiv \mathbb{1}_{\{2\leq\text{experience}_{h,t}\leq 3\}}$); medium experience ($\text{med\_experience}_{h,t} \equiv \mathbb{1}_{\{3\leq\text{experience}_{h,t}\leq 5\}}$); and high experience ($\text{high\_experience}_{h,t} \equiv \mathbb{1}_{\{6\leq\text{experience}_{h,t}\}}$) where $\mathbb{1}_{\{\cdot\}}$ is an indicator function. We take low experience as the omitted baseline and estimate dummies for the medium and high groups alongside the switching dummy:

$$\begin{aligned}\Delta\text{size}_{h,t} = {} & \alpha_{\text{Med}}\text{med\_experience}_{h,t} + \alpha_{\text{High}}\text{high\_experience}_{h,t} + \beta\text{brand\_switching}_{h,t} \\ & + \mathbf{x}_{h,t}^{'}\theta + \delta_h + \gamma_{t_y} + \gamma_{t_m} + \epsilon_{h,t}.\end{aligned} \tag{2}$$

The coefficients translate our hypotheses into sign predictions. Hypothesis 1 predicts positive, increasing coefficients, $0 < \alpha_{\text{Med}} < \alpha_{\text{High}}$: size growth rises with experience. Hypothesis 2 predicts $\beta < 0$: relative to the baseline, switching lowers size growth. Together, $\beta < \alpha_{\text{Med}}, \alpha_{\text{High}}$ confirm that staying yields higher size growth than switching.

Other Controls and Fixed Effects. Alongside the experience and brand-switching variables, we include a set of controls, $\mathbf{x}_{h,t}$ for time-varying confounders specific to household h at trip t, including log time elapsed from the first purchase of each brand and the growth rate of price paid. We select the controls with the lasso from a set of 1,033 candidates: features of the product bought on the current and previous trips, and interactions between current and lagged state variables. Appendix Table A.2 lists the selected variables and describes the selection procedure. For example, consumers who change stores may revise their consideration sets, increasing the likelihood of brand switching; accordingly, the controls include a store-change indicator.[3]

A further confounder is persistent variation across locations, such as urban versus rural areas, that plausibly affects both experience with a brand and purchase size. For example, if a consumer in a rural area has access to only one store that supplies a single brand or size, a change in what that store stocks could produce a spurious association between brand switching and purchase size. It is equally important to control flexibly for aggregate trends. National trends in brand choice and in size could move together over the same period while being driven by entirely different factors. Without controls, one would then mistakenly attribute a rise in purchase size to rising experience.

Our regression therefore includes two sets of fixed effects. First, δ_h absorbs time-invariant heterogeneity through fixed effects at the regional market, household, and household-spell level, depending on the specification. Second, γ_{t_y} and γ_{t_m} denote year and month effects, where t_y and t_m index the calendar year and month; these control flexibly for aggregate trends and seasonality.

3.2. Regression Results

The estimated coefficients of regressions support both hypotheses: within-spell experience is positively associated with purchase size growth, and brand switching is negatively associated with it. These findings hold across specifications.

Table 2 reports the experience coefficient, α in equation (1), under two measures. Our benchmark measure (the number of previous purchases within the spell) enters positively and is significant at the 1% level in columns (1) and (3) (0.0027 and 0.0085; standard errors 0.0006 and 0.0010). The result is robust to using the log cumulative quantity purchased within the spell as an alternative measure. Purchase size thus rises with experience with the chosen brand. Furthermore, Columns (2) and (4) drop the top 5% of spells by length

[3]We also examine whether high-frequency shoppers exhibit stronger state dependence and find no significant relationship between shopping frequency and brand preference, mitigating concerns that our results reflect shopping habits.

Table 2: Regression Results of Size Growth and Brand Experience

	Dependent Variable: Size Growth			
	(1)	(2)	(3)	(4)
Number of previous purchases	0.0027***		0.0085***	
	(0.0006)		(0.0010)	
Log cumulative quantity		0.0040***		0.0042***
		(0.0012)		(0.0013)
Growth rate of price paid	−0.5300***	−0.5299***	−0.5265***	−0.5267***
	(0.0067)	(0.0067)	(0.0069)	(0.0069)
$\ln(\text{date}_t - \text{date}_{t-1})$	−0.0221***	−0.0227***	−0.0212***	−0.0226***
	(0.0015)	(0.0015)	(0.0016)	(0.0015)
Other controls	✓	✓	✓	✓
Household FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Month FE	✓	✓	✓	✓
Excluding extreme spells			✓	✓
Observations	85,382	85,382	75,883	75,883
Number of Households	10,570	10,570	10,570	10,570
Within R-squared	0.5001	0.4998	0.5116	0.5110

Notes:*p<0.1, **p<0.05, ***p<0.01. Standard errors in parentheses are clustered within households.

Table 3: Regression Results of Size Growth and Brand Switching Decisions

	Dependent Variable: Size Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Number of previous purchases		0.0026***			0.0080***	
		(0.0006)			(0.0010)	
Dummies for experience						
Brand switching	−0.0186***	−0.0156***	−0.0136**	−0.0250***	−0.0141**	−0.0215***
$\mathbb{1}(\text{experience} = 0)$	(0.0054)	(0.0054)	(0.0054)	(0.0056)	(0.0056)	(0.0056)
Medium experience			0.0264***			0.0303***
$\mathbb{1}(3 \leq \text{experience} \leq 5)$			(0.0048)			(0.0050)
High experience			0.0574***			0.0611***
$\mathbb{1}(6 \leq \text{experience})$			(0.0069)			(0.0074)
Growth rate of price paid	−0.5303***	−0.5297***	−0.5296***	−0.5269***	−0.5262***	−0.5262***
	(0.0067)	(0.0067)	(0.0067)	(0.0069)	(0.0069)	(0.0069)
$\ln(\text{date}_t - \text{date}_{t-1})$	−0.0230***	−0.0221***	−0.0217***	−0.0228***	−0.0213***	−0.0213***
	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0016)	(0.0016)
Other controls	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Month FE	✓	✓	✓	✓	✓	✓
Excluding extreme spells				✓	✓	✓
Observations	85,382	85,382	85,382	75,883	75,883	75,883
Number of Households	10,570	10,570	10,570	10,570	10,570	10,570
Within R-squared	0.4998	0.5002	0.5003	0.5111	0.5116	0.5116

Notes:*p<0.1, **p<0.05, ***p<0.01. Standard errors in parentheses are clustered within households. Dummies for experience are defined based on experience (the number of previous purchases within the spell). The omitted category is low experience ($\text{experience} \in \{1, 2\}$) in Columns (3) and (6).

(above 17) and the top 5% of households by number of spells (above 9). These tails contain consumers with many spells, where size and switching may reflect satiation or variety-seeking rather than the experience response we study. The sub-sample estimates are qualitatively indistinguishable from the full-sample results.

Table 3 examines brand switching. Columns (1) and (4) include the switching dummy alone; its coefficient, β in equation (2), is significantly negative, so switchers buy smaller sizes than on their previous trip. Columns (2) and (5) add within-spell experience: experience remains positive and switching negative, though these estimates should be read with care, given the strong negative correlation (-0.345 Pearson correlation coefficient) between the two regressors. Columns (3) and (6) report the categorical specification in equation (2). The switching coefficient is significantly negative, while the medium- and high-experience dummies are significantly positive at the 1% level, with the high-experience category exceeding the medium ($0 < \alpha_{\text{Med}} < \alpha_{\text{High}}$). More experienced consumers therefore show higher size growth, consistent with Table 2.

Additionally, time elapsed since the previous purchase ($\ln(\text{date}_t - \text{date}_{t-1})$) enters negatively across specifications in Tables 2 and 3. Consumers buy smaller sizes as the value of past information decays, consistent with rising uncertainty over time. We leave a full treatment of this decay channel to future work.

The regressions establish two robust facts: purchase size grows with within-spell experience and falls upon switching. These reduced-form patterns describe how much consumers buy as a brand relationship develops, but they do not by themselves identify the mechanism behind them. The next section develops a model of brand and quantity choice with learning about product quality and shows that such a model reproduces both patterns, offering learning as a natural account of the size response.

Robustness: Margarine Market. To assess generalizability, we replicate the analysis in margarine, a perishable category with minimal stockpiling. Appendix Table A.3 and Figure A.1 reproduce our two patterns: purchase size grows with within-spell experience and falls upon switching.

4. A Dynamic Model of Brand and Size Choice

To rationalize the empirical findings, we develop a dynamic model in which consumers choose both a brand and a purchase size under uncertainty about product quality. Bayesian learning models of brand choice—from Roberts and Urban (1988) to Erdem and Keane (1996) and Ching, Erdem and Keane (2013)—typically normalize quantity to one, abstracting from size. By modeling brand and size jointly, our model shows how learning about quality moves both brand switching and purchase size together, offering a natural account of the patterns in Section 3.

4.1. Model Environment

We describe the environment and derive the indirect utility function that governs each shopping trip and forms the foundation of the dynamic problem.

Uncertainty and Learning. Before the first purchase, consumers are uncertain about an unobserved brand attribute (quality or flavor). We adopt a one-shot, perfect-learning assumption: consumers begin with a known prior over the attribute and, upon a single purchase, learn its true attribute perfectly and permanently. This assumption fits the cough-drop setting—one trial is typically enough to judge a brand—and keeps the dynamic problem tractable while preserving the two channels at the center of our analysis: uncertainty resolution and selection on realized quality. With gradual Bayesian updating, the trial penalty derived below would shrink over several purchases rather than vanish after one; the qualitative predictions are unchanged. Following Erdem and Keane (1996) and Ching, Erdem and Keane (2013), we call the latent attribute "quality," q_i, for brand $i \in \mathcal{I}$, and take it to be log-normally distributed:

$$\ln(q_i) \sim \mathcal{N}(-0.5\sigma_q^2 + \ln \mu_q, \sigma_q^2).$$

This specification implies a prior mean $\mathbb{E}[q_i] = \mu_q$ and a coefficient of variation (the ratio of the standard deviation to the mean) $\sqrt{\exp(\sigma_q^2) - 1}$, where σ_q^2 captures initial quality uncertainty.

Preference. Let size_i denote the purchase quantity of brand i. Utility increases with both perceived quality and purchase size and is subject to an idiosyncratic preference shock s_i, observed at the start of each trip:

$$\ln(s_i) \sim \mathcal{N}(-0.5\sigma_s^2, \sigma_s^2).$$

We focus on products with negligible budget shares, eliminating income effects. The consumer's quasi-linear utility in the numeraire good x given total budget w is

$$
\begin{aligned}
& x + \mathbb{E}\left[\sum_{i \in \mathcal{I}} 2\sqrt{s_i q_i \mathsf{size}_i} \,\middle|\, \{s_i, e_i\}_{i \in \mathcal{I}} \right] \\
&= x + 2 \sum_{i \in \mathcal{I}} \left\{ \mathbb{1}_{\{e_i \geq 1\}} \times \underbrace{\sqrt{s_i q_i \mathsf{size}_i}}_{\substack{\text{if brand } i \text{ is} \\ \text{experienced.}}} + \mathbb{1}_{\{e_i = 0\}} \times \underbrace{\sqrt{s_i} \mathbb{E}\left[\sqrt{q_i}\right] \sqrt{\mathsf{size}_i}}_{\substack{\text{if brand } i \text{ is} \\ \text{not experienced.}}} \right\},
\end{aligned}
\tag{3}
$$

where e_i denotes the number of previous purchase with the spell and records prior experiences with brand i; under one-shot learning only $e_i = 0$ (untried) versus $e_i \geq 1$ (experienced) matters. Because brands are perfect substitutes, consumers purchase the single brand maximizing expected utility per unit price on a given trip.

Indirect Utility and Size Choice. For any chosen brand i, the consumer selects purchase size to maximize utility, yielding the indirect utility function:

$$
u(e_i; q_i, s_i/p_i) = \begin{cases} \dfrac{s_i}{p_i} q_i + w & \text{if } e_i \geq 1 \ (q_i \text{ observable}) \\ \dfrac{s_i}{p_i} \{\mathbb{E}[\sqrt{q_i}]\}^2 + w & \text{otherwise} \end{cases}, \tag{4}
$$

where $\{\mathbb{E}[\sqrt{q_i}]\}^2 = \mu_q \exp(-\sigma_q^2/4)$ is the certainty-equivalent quality for an inexperienced, risk-averse consumer. Learning increases utility by resolving quality uncertainty (σ_q).

The corresponding optimal purchase size is:

$$
\mathsf{size}_i = size(e_i; q_i, s_i/p_i) \equiv \begin{cases} \dfrac{s_i}{p_i^2} q_i & \text{if } e_i \geq 1 \ (q_i \text{ observable}) \\ \dfrac{s_i}{p_i^2} \{\mathbb{E}[\sqrt{q_i}]\}^2 & \text{otherwise} \end{cases}. \tag{5}
$$

This formulation predicts that experienced consumers buy larger sizes of higher-quality brands, and that untried brands with greater quality uncertainty induce smaller trial purchases. Risk aversion here is not a separate parameter but the concavity of utility in quality: the trial discount $\exp(-\sigma_q^2/4)$ follows directly from Jensen's inequality applied.

4.2. Dynamic Problem

We embed the static choice framework within a dynamic programming structure with two brands, indexed by $i \in \{o, n\}$, the old (incumbent) and new brands. The two-brand structure isolates the mechanism; the empirical analysis uses the full Halls–Ricola–outside

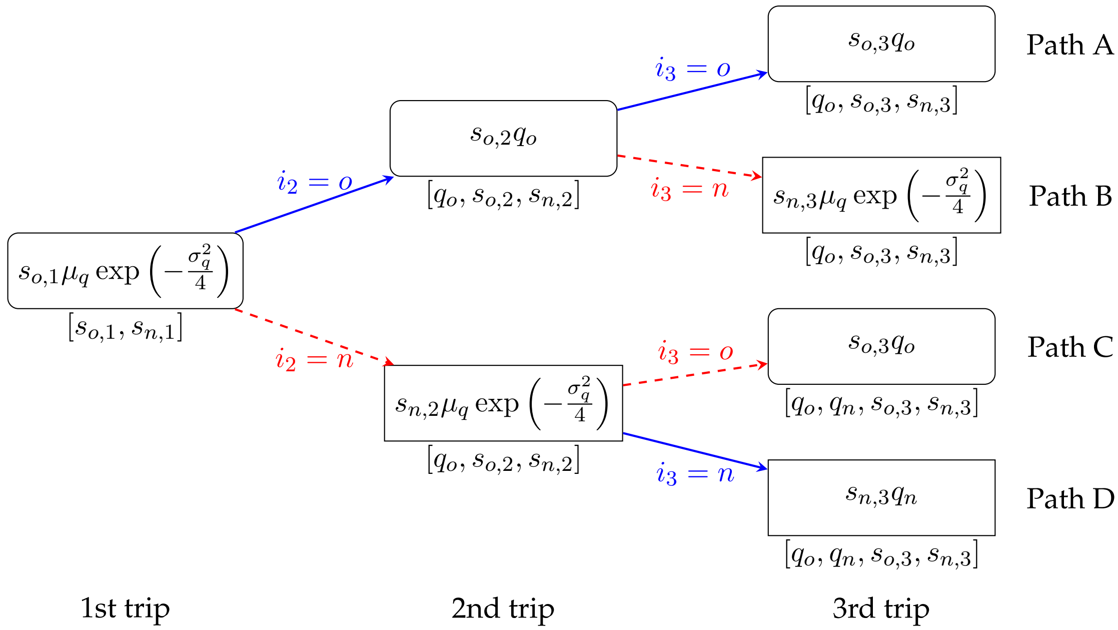

Figure 2: Dynamic Problem: Brand and Size Choices ($t = 1, 2, 3$)

Notes: The figure illustrates the sequence of choices and information sets across trips. Size is in boxes. Information at the beginning of each path is shown below boxes. Rounded vs. squared nodes represent old vs. new brand choices, and dashed red arrows indicate brand switching.

choice set. The model has a finite horizon of $T \geq 3$ shopping trips, corresponding to a purchase spell: the year-long gaps of Section 2 reset experience, so each trajectory begins in the untried state $e = 0$. Prices and income are fixed and known throughout, with prices normalized to one ($p_{i,t} = 1$). So, only the preference shocks $s_{i,t}$ vary over time. This isolate how experience shapes brand and size choices. Figure 2 illustrates how information and choices evolve across trips.

For each shopping trip t, the consumer chooses a brand i_t by solving the value function:

$$V_t(\mathbf{e}_t; \mathbf{q}, \mathbf{s}_t) = \max\left\{V_t^o(\mathbf{e}_t; \mathbf{q}, \mathbf{s}_t), V_t^n(\mathbf{e}_t; \mathbf{q}, \boldsymbol{s}_t)\right\}, \tag{6}$$

where the preference shocks $\mathbf{s}_t$ are observed, while the latent qualities $\mathbf{q}$ are known or unknown depending on experience $\mathbf{e}_t$. The conditional value on choosing brand i is:

$$V_t^i(\mathbf{e}_t; \mathbf{q}, \mathbf{s}_t) = u(e_{i,t}; q_i, s_{i,t}) - \chi \mathbb{1}_{\{i \neq i_{t-1}\}} + \varrho \mathbb{E}_t[V_{t+1}(\mathbf{e}_{t+1}; \mathbf{q}, \mathbf{s}_{t+1})], \tag{7}$$

where $u(\cdot)$ is the indirect utility from equation (4), $\varrho \in [0, 1]$ is the discount factor, $\chi \geq 0$ is an exogenous fixed cost of switching brands, and $\mathbb{1}_{\{i \neq i_{t-1}\}}$ indicates switching away from the previous brand. Including χ lets the model nest a pure brand switching-cost account, which the counterfactuals (Section 3) use to ask whether fixed costs for brand switching alone could reproduce the size patterns. At $t = 1$, no brand has been chosen, so no switching cost applies. The consumer's initial brand is the old brand ($i_1 = o$), which holds whenever $s_{o,1} \geq s_{n,1}$.

The initial value function ($V_1 = V_1^o$) reduces to:

$$V_1([0;0];\mathbf{q},\mathbf{s}_1) = s_{o,1}\mu_q \exp\left(-\frac{\sigma_q^2}{4}\right) + w + \varrho\mathbb{E}_1[V_2([1;0];\mathbf{q},\mathbf{s}_2)]. \tag{8}$$

At the terminal period T, no continuation value remains, so the decision reduces to comparing immediate utilities:

$$V_T([1,e_{n,T}];\mathbf{q},\mathbf{s}_T) = \max\left\{s_{o,T}q_o - \chi\mathbb{1}_{\{i_{T-1}=n\}}, u(e_{n,T};q_n,s_{n,T}) - \chi\mathbb{1}_{\{i_{T-1}=o\}}\right\}. \tag{9}$$

4.3. Optimal Brand Choice

On each shopping trip t, the consumer decides whether to remain loyal to the previously chosen brand i_{t-1} or switch to the alternative brand $j \neq i_{t-1}$ by comparing the expected values of each option. This decision reflects a trade-off between immediate utility and the expected future value of information from trying an untried brand.

We define the net value of switching from i_{t-1} to j as the "value gap," $B_t^{i_{t-1}}(\mathbf{e}_t;\mathbf{q},\mathbf{s}_t) \equiv V_t^j(\mathbf{e}_t;\mathbf{q},\mathbf{s}_t) - V_t^{i_{t-1}}(\mathbf{e}_t;\mathbf{q},\mathbf{s}_t)$, which decomposes into present and future gains:

$$\begin{aligned} B_t^{i_{t-1}}(\mathbf{e}_t;\mathbf{q},\mathbf{s}_t) = &\overbrace{u(e_j;q_j,s_{j,t}) - u(e_{i_{t-1}};q_{i_{t-1}},s_{i_{t-1},t}) - \chi}^{F_t^{i_{t-1}}:\text{ present gains}} \\ &+ \varrho\,\underbrace{\mathbb{E}_t[V_{t+1}([e_{i_{t-1}},e_j+1];\mathbf{q},\mathbf{s}_{t+1}) - V_{t+1}([e_{i_{t-1}}+1,e_j];\mathbf{q},\mathbf{s}_{t+1})]}_{G_t^{i_{t-1}}:\text{ future gains}}, \end{aligned} \tag{10}$$

which implies that the consumer switches to brand $j(\neq i_{t-1})$ if and only if $B_t^{i_{t-1}} > 0$. The present gain $F_t^{i_{t-1}}$ is the immediate utility difference, net of the switching cost χ, while the future gain $G_t^{i_{t-1}}$ is the option value of information from trying brand j, which improves future decision. This option value is positive only when brand j is untried—trying an already-experience brand resolves no uncertainty.

The Case with $T = 3$. Consider $T = 3$, sufficient to capture the core dynamics of learning, brand switching, and purchase-size adjustment. At the terminal trip $t = 3$, no future gains remain, so brand choice depends only on current utility—a function of preference shocks

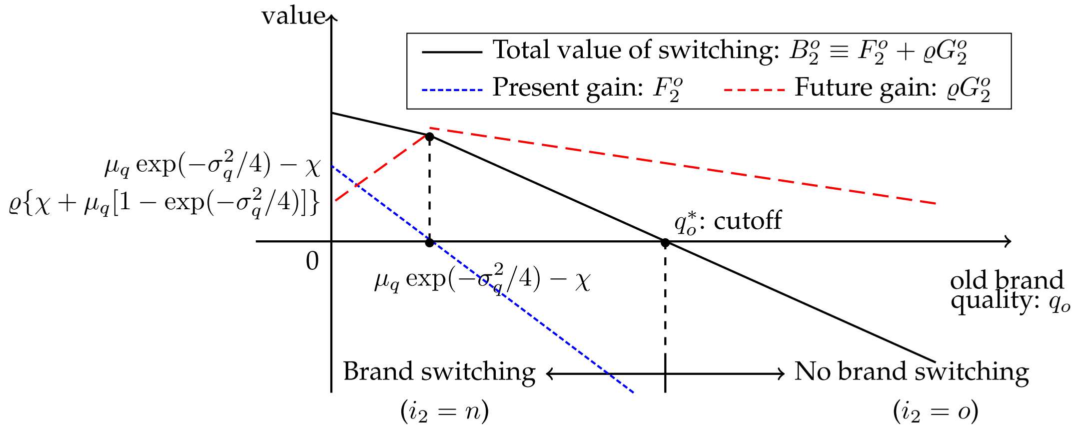

Figure 3: Optimal Brand Switching at the Second Shopping Trip with $T = 3$

Notes: The figure illustrates the components of the switching decision at $t = 2$, assuming no preference shocks ($\sigma_s = 0$, so $s_{o,2} = s_{n,2} = 1$). The consumer switches if $B_2^o > 0$, which occurs when the old brand's realized quality (q_o) is below the cutoff q_o^*. The restriction $\mu_q \exp(-\sigma_q^2/4) > \chi$ guarantees a positive cutoff.

and known quality—and switching cost:

$$V_3(\mathbf{e}_3; \mathbf{q}, \mathbf{s}_3) = \begin{cases} \max\left\{s_{o,3}q_o - \chi,\ s_{n,3}q_n\right\} + w & \text{if } e_{n,3} = 1\ (i_2 = n) \\ \max\left\{s_{o,3}q_o,\ s_{n,3}\mu_q \exp\left(-\frac{\sigma_q^2}{4}\right) - \chi\right\} + w & \text{otherwise} \end{cases}. \tag{11}$$

The decision depends only on past experience, current preference shocks, and the observed old brand quality.

The core dynamic trade-off is captured at the second trip $t = 2$. Having experienced brand o ($e_{o,2} = 1$), the consumer knows its quality q_o but remains uncertain about n ($e_{n,2} = 0$). The present gain from switching to the new brand is

$$F_2^o([1, 0]; \mathbf{q}, \mathbf{s}_2) = s_{n,2}\mu_q \exp\left(-\frac{\sigma_q^2}{4}\right) - s_{o,2}q_o - \chi, \tag{12}$$

which decreases as q_o increases: discovering that the old brand is high quality diminishes the incentive to experiment with the unknown new brand.

Switching also yields future benefits by resolving uncertainty about the new brand's quality. The expected future gain, or option value, is:

$$G_2^o([1; 0]; \mathbf{q}) = \mathbb{E}\left[\max\{s_{o,3}q_o - \chi, s_{n,3}q_n\}\middle|q_o\right] - \mathbb{E}\left[\max\left\{s_{o,3}q_o, s_{n,3}\mu_q \exp\left(-\frac{\sigma_q^2}{4}\right) - \chi\right\}\middle|q_o\right]. \tag{13}$$

This term is the value of making a fully informed choice at $t = 3$; it is larger when the

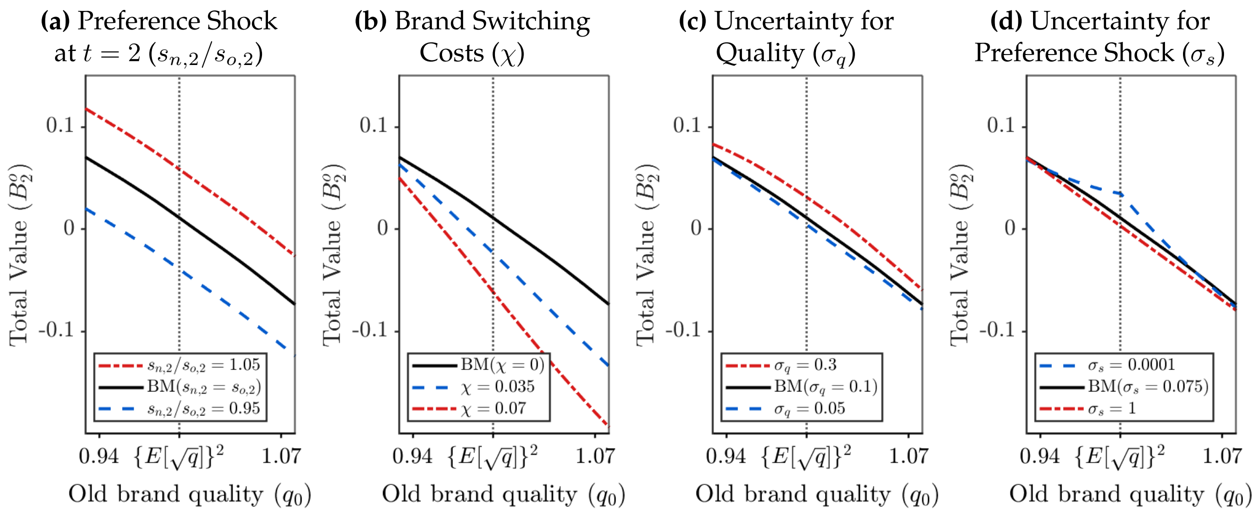

Figure 4: Parameters and Optimal Brand Switching at the Second Shopping Trip

Notes: The total value B_2^o represents the value gap between choosing the new brand and staying with the old brand at the second shopping trip defined in equation (10). Panel (a) varies the relative preference shock ratio $(s_{n,2}/s_{o,2})$. Panel (b) shows the effect of fixed costs of switching brands (χ). Panel (c) illustrates the impact of quality uncertainty (σ_q). Panel (d) considers preference-shock uncertainty (σ_s). The benchmark case (BM) refers to the parameterization with $s_{n,2} = s_{o,2} = 1$, $\chi = 0$, $\sigma_q = 0.1$, and $\sigma_s = 0.075$.

switching cost χ is low, since the consumer can more easily act on her new knowledge in the final period.

Figure 3 illustrates the $t = 2$ choice with shocks fixed ($\sigma_s = 0$, so $s_{o,2} = s_{n,2} = 1$). The gains from trying the new brand decline with the observed old-brand quality, giving a cutoff rule: if $q_o < q_o^*$, the consumer switches; if $q_o \geq q_o^*$, she stays. A higher cutoff means the consumer stays over a wider range of realized quality.

Brand Switching and Parameters. Figure 4 extends the cutoff analysis, tracing how the value gap $B_2^o \equiv V_2^n - V_2^o$ responds to the model's structural parameters. We solve the value function numerically and vary each parameter around a benchmark ($\mu_q = 1$, $\varrho = 0.99$, $\sigma_q = 0.1$, $\sigma_s = 0.075$, $\chi = 0$; the calibration is described in Section 5). For clarity, the plots hold preference shocks constant, normalizing $s_{o,2} = 1$ and fixing the shock ratio at one except in Panel (a), which varies it.

Across all parameter variations, the gains from switching decline as the old brand's realized quality rises, consistent with the cutoff rule in Figure 3. Consumers highly satisfied with the old brand face weaker incentives to explore alternatives. Elevated switching frictions and volatile preference shocks lower both immediate and future gains from switching, further discouraging it. Higher quality uncertainty, by contrast, raises the value of information, encouraging switching as consumers seek to resolve that uncertainty.

5. Model Implications for Size, Experience and Switching

This section derives the model's testable implications for purchase size, experience, and brand switching. We show how uncertainty resolution and selection on realized quality move purchase size, offering a natural account of the patterns in Section 3. To illustrate, we simulate purchase histories from the numerically solved model.

Parameterization and Simulation. We simulate optimal brand and size choices from random draws of brand quality values and preference shocks. The simulation extends the Section 4 model with a stochastic horizon: after each trip the consumer continues shopping with probability π, capturing the finite but uncertain length of a purchase spell. We specify a five-period model ($T = 5$) with a continuation probability of $\pi = 1$ for $t \leq 3$ and $\pi = 0.675$ for $t \geq 4$. We draw 1,000 quality pairs $\{q_o, q_n\}$ from their distributions and, for each, 100 preference-shock pairs $\mathbf{s}_t = [s_{o,t}, s_{n,t}]$. At $t = 1$, the consumer begins with the old brand ($i_1 = o$), whenever $s_{o,1} > s_{n,1}$.

The benchmark parameters ($\sigma_q = 0.1$, $\sigma_s = 0.075$) are calibrated to match key features of observed purchase histories—average spell length, number of spells, and switching probability—yielding an average spell length of 2.41, 2.52 spells per consumer, and a 38% switching probability, consistent with the cough-drop market.

5.1. Size Choice and Brand Experience

While brand choice is dynamic and forward-looking, the quasi-linear utility framework makes purchase size static conditional on the chosen brand. From equation (5), the optimal purchase size on trip t for the chosen brand i_t is:

$$\mathsf{size}_t = size(i_t, e_{i,t}, q_i, s_{i,t}) \equiv \begin{cases} s_{i_t,t} q_{i_t} & \text{if } e_{i_t} \geq 1 \ (q_{i_t} \text{ observable}) \\ s_{i_t,t} \mu_q \exp\left(-\frac{\sigma_q^2}{4}\right) & \text{otherwise.} \end{cases} \tag{14}$$

Consumers thus buy smaller sizes of an untried brand, reduced by a factor of $\exp(-\sigma_q^2/4)$ from risk aversion toward quality uncertainty. Figure 5 shows the simulated purchase size distributions across all choice histories (Paths A–D). We denote the brand-choice history (path) from the first through the T-th shopping trip by $\mathbf{i}_1^T \equiv [i_1; \cdots; i_T]$.

The model predicts that purchase size grows systematically with experience within a spell (Definition 1). For the growth between trips $t - 1$ and t, conditional on staying with the same brand $i = i_t = i_{t-1}$,

$$\Delta \ln \mathsf{size}_t^{i_t = i_{t-1}} = \begin{cases} \Delta \ln s_{i,t} + \ln \dfrac{q_{i_t}}{\mu_q} + \dfrac{\sigma_q^2}{4} & \text{if } e_{i,t} = 1 \text{ (after the initial trial)} \\ \Delta \ln s_{i,t} & \text{if } e_{i,t-1} \geq 2 \end{cases} . \tag{15}$$

Uncertainty Resolution and Selection on Realized Quality. Two key mechanisms drive size growth after the initial trial: *(i) Uncertainty Resolution:* after the first purchase, quality uncertainty is resolved. For a risk-averse consumer, removing this uncertainty mechanically raises the next purchase size by $\sigma_q^2/4$, holding all else equal— a direct consequence of learning. *(ii) Selection on Realized Quality:* the term, $\ln q_{i_t}/\mu_q$ captures the brand's true quality. A consumer's repeat-purchase decision is endogenous: she stays with a brand ($i_t = i_{t-1} = i$) when its realized quality is high ($q_i > \mu_q$) and switches when it disappoints. A low draw ($q_{i_t} < \mu_q$) therefore rarely survives optimal choice, so within-spell continuation selects on high quality, and accumulated experience coincides with larger sizes.

Simulations in Figure 5 support both channels: in Paths A ($o \to o \to o$) and C($o \to n \to n$), mean purchase size rises after the first repeat purchase (from trip 1 to 2 in Path A; from trip 2 to 3 in Path C).

Growth does not stop there. Even with quality fully known (e.g., the third trip in Path A), selection continues through preference shocks: the consumer buys brand o a third time only if the shock $s_{o,3}$ is high enough to prevent a switch to brand n. This selection on favorable shocks sustains positive average size growth deeper into the spell—the rising mean from the second to third trip in Path A—reproducing the monotone within-spell profile in Figure 5.

Figure 6 confirms these channels. Panel (a) shows size growth at $t = 2$: when within-spell experience increases ("Yes," Path A or B), average growth is positive, reflecting the combined uncertainty-resolution and selection effects. Panel (b) shows growth at $t = 3$: the "Yes" case includes consumers making their first repeat purchase (Path C) or their second (Path A), and average growth is again positive, driven by the same mechanisms plus selection on favorable preference shocks for those already experienced.

Brand Experience Increases Purchase Size. Both channels—uncertainty resolution and selection on realized quality—raise purchase size with accumulated experience, providing the model counterpart to the positive experience coefficient in Tables 2 and 3 (Hypothesis 1).

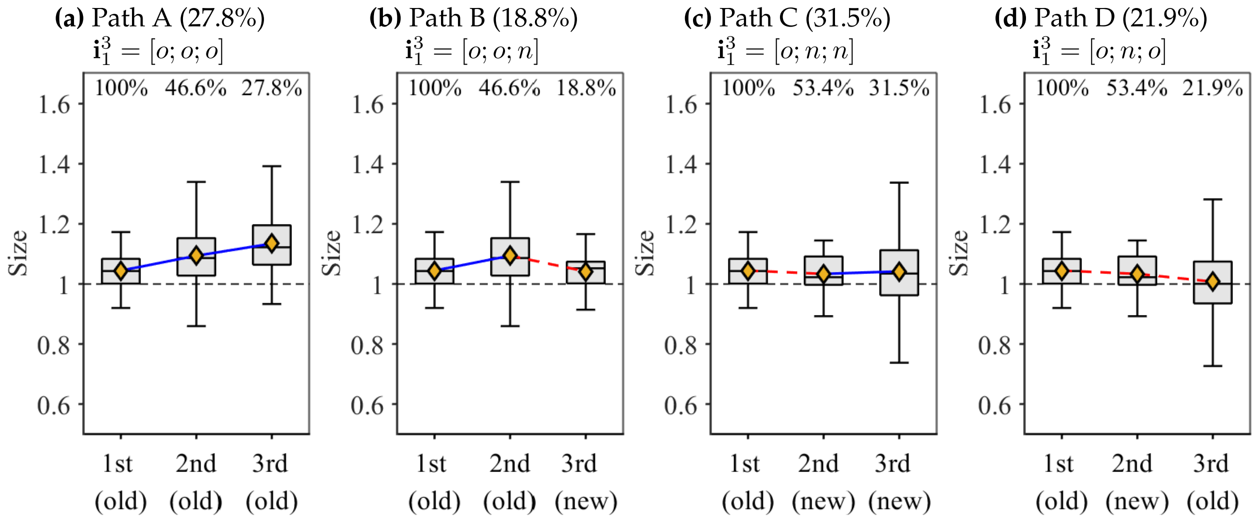

Figure 5: Distribution of Size Choices by Brand Choice History ($t = 1, 2, 3$)

Notes: The figure reports the simulated distribution of size choices by brand choice path. We plot the first, second, and third quartiles and mean (yellow diamond) values of sizes for each path. The dashed red lines indicate brand switching. Outside values are shown as gray dots. See Appendix Figure A.4 for the whole brand choice history from $t = 1$ to $t = 5$.

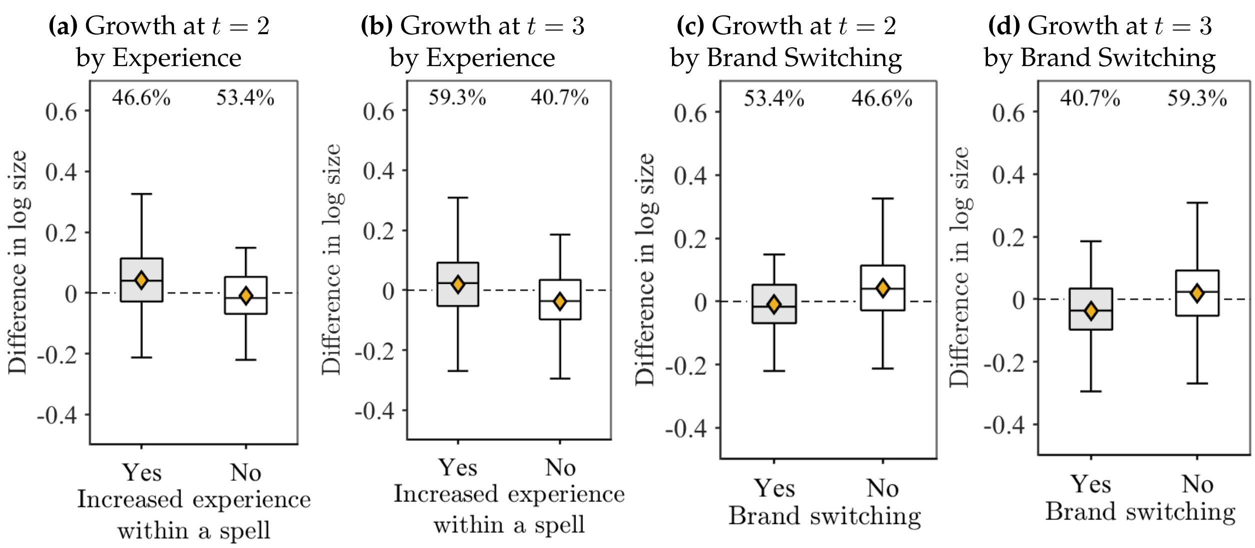

Figure 6: Distribution of Size Growth with Experience and Brand Switching

Notes: Outside values are shown as gray dots. The figure reports the simulated first, second, and third quartiles and mean (yellow diamond) values of size growth with and without an increase in within-spell experience (Panels a and b) as well as with and without brand switching (Panels c and d). See Figure A.2 for the corresponding size choice distributions.

5.2. Size Choice and Brand Switching

Brand switching is closely tied to the learning and selection process. We analyze how switching correlates with purchase size growth, on the intuition that consumers stay with brands that satisfy them and switch when disappointed or tempted by better options. This asymmetry links brand loyalty to larger sizes and switching to smaller ones.

Brand Switching at the Second Trip ($t = 2$). After trying the old brand, the consumers learns its true quality, q_o; her decision to stay or switch then reveals that quality to us. Without a switch (Paths A & B), she repeats the old brand ($i_2 = o$) only if its realized quality q_o is high enough to justify forgoing the option to learn about the new brand. This yields positive size growth for two reasons: *(i)* uncertainty resolution, which removes the initial trial penalty and *(ii)* selection on realized quality ($q_o > \mu_q$ on average). With a switch (Paths C & D), she moves to the new brand ($i_2 = n$) because the old brand's quality q_o disappointed, making a trial purchase of an unknown product.

The resulting size growth at $t = 2$ is:

$$\Delta \ln \mathsf{size}_2 = \begin{cases} \ln \dfrac{s_{n,2}}{s_{o,1}} & \text{if } i_2 = n \text{ (Switching, Paths C and D)} \\ \Delta \ln s_{o,2} + \ln \dfrac{q_o}{\mu_q} + \dfrac{\sigma_q^2}{4} & \text{if } i_2 = o \text{ (Staying, Paths A and B)} \end{cases} . \tag{16}$$

The comparison is stark. Consumers who stay gain from both a favorable quality draw (high q_o) and the mechanical boost of uncertainty resolution. Switchers, by contrast, buy an untried brand, so their size growth depends only on the relative preference shocks. Panel (c) of Figure 6 confirms the larger growth for non-switchers.

Brand Switching at the Third Trip ($t = 3$). The logic extends to the third trip, conditional on the previous choice i_2.

(i) Case of $i_2 = o$: the consumer was satisfied with the old brand at $t = 2$. Switching to the new brand now (Path B) requires a strong preference shock ($s_{n,3}$) to overcome both the known high quality of brand o and the switching cost; and since this is still a first purchase of n, the trial penalty applies. The size growth is:

$$\Delta \ln \mathsf{size}_3^{i_2=o} = \begin{cases} \ln \dfrac{s_{n,3}}{s_{o,2}} - \ln \dfrac{q_o}{\mu_q} - \dfrac{\sigma_q^2}{4} & \text{if } i_3 = n \text{ (Switching, Path B)} \\ \Delta \ln s_{o,3} & \text{if } i_3 = o \text{ (Staying, Path A)} \end{cases} . \tag{17}$$

Switching generates strongly negative size growth: the consumer moves from a known, high-quality brand (large q_o in the denominator) to an unknown one (the uncertainty penalty), so purchase size shrinks.

(ii) Case of $i_2 = n$: the consumer was disappointed by brand o and tried n at $t = 2$, so by $t = 3$ she knows both qualities and choose by direct comparison. Without a switch (Path C), staying with the new brand ($i_3 = n$) implies q_n was high—a successful trial. With a switch (Path D), returning to the old brand ($i_3 = o$) implies q_n also disappointed, making the known (and likely mediocre) q_o the better of two poor options.

The chosen brand's quality is higher for stayers than for switchers when $i_2 = n$, and size growth reflects it:

$$\Delta \ln \text{size}_3^{i_2=n} = \begin{cases} \ln \frac{s_{o,3}}{s_{n,2}} + \ln \frac{q_o}{\mu_q} + \frac{\sigma_q^2}{4} & \text{if } i_3 = o \text{ (Switching, Path D)} \\ \ln \frac{s_{n,3}}{s_{n,2}} + \ln \frac{q_n}{\mu_q} + \frac{\sigma_q^2}{4} & \text{if } i_3 = n \text{ (Staying, Path C)} \end{cases} . \tag{18}$$

Stayers keep brand n because its quality is high ($\mathbb{E}[\ln q_n|\text{Path C}] > \ln \mu_q$), whereas switchers return to o despite its low realized quality ($\mathbb{E}[\ln q_o|\text{Path D}] < \ln \mu_q$), so size growth is again lower for switchers.

Brand Switching Lowers Purchase Size. Across all scenarios, brand switching is associated with disappointment in the current brand or uncertainty about a new one, both of which lower purchase size; repeat purchasing, by contrast, confirms a known, high-quality brand and raises it. Figure 6 beats this out: for both $t = 2$ and $t = 3$, median and mean purchase-size growth are negative following a switch and positive otherwise. This matches the estimated negative switching coefficient (β) in Table 3 (Hypothesis 2).

5.3. Counterfactual Exercises

Switching costs are the leading alternative account of state dependent brand choice in this literature (Dubé, Hitsch and Rossi 2010), so we ask whether the two size signatures—a positive experience effect and a negative switching effect—could arise from switching costs alone. We run two exercises: first shutting learning off entirely, then keeping learning on while raising switching costs. Neither reproduces the signatures, and at high switching costs the friction-driven world produces their mirror image.

Counterfactual 1: Switching Costs Without Learning. Without learning, the experience–size relationship disappears. We set quality uncertainty negligible ($\sigma_q = 0.0001$) and add a modest switching cost ($\chi = 0.035$) calibrated to match the benchmark switching frequency.[4] This removes both learning channels: uncertainty resolution gives no size bonus on repeat purchase, and the option value of experimentation is zero, so switching reflects only the immediate utility–cost trade-off. Any remaining size dynamics come from preference shocks and switching costs alone.

Figure 7 confirms it: median growth for repeat purchasers centers on zero, indistinguishable from non-repeaters (Panels a–b). A weaker negative switching correlation remains–consumers still abandon low-quality draws—but non-switchers no longer show positive growth (Panels c–d). Switching costs alone reproduce neither pattern.

Counterfactual 2: Learning with High Frictions. We next retain baseline learning ($\sigma_q = 0.1$) and raise the switching cost, $\chi \in \{0.1, 0.2, 0.3, 0.4\}$. High frictions induce inertia: consumers experiment less and retain brands that are merely good enough, which weakens the selection channel. At $\chi = 0.2$ the learning signatures persist but are muted (Appendix Figure A.3).

Figure 8 traces both effects across the full range of χ, and the sharp result is a sign reversal. At $\chi = 0$ the signatures match the learning predictions exactly. As χ rises they attenuate, and at $\chi = 0.4$ both flip: the experience effect turns negative and the switching effect positive. The mechanism is that under high frictions a switch occurs only after an unusually large preference shock s_n, so post-switch purchases—proportional to s—are large, while stayers include many locked-in holders of mediocre brands, so experience no longer selects on high quality. A friction-dominated world does not merely fail to reproduce the learning signatures; it generates their mirror image.

The counterfactuals thus show that the size signatures of learning are distinct from those of switching costs—and at high frictions, opposite. The empirical tests of Section 3 therefore distinguish learning from a pure switching-cost account.

5.4. Discussion: Scope of the Learning Account

The model reproduces both empirical patterns documented in the data: purchase size grows with within-spell experience and falls upon brand switching. The counterfactuals in Section 3 show that learning well-reproduces these patterns, but they cannot arise from exogenous switching costs alone. Under sufficiently high switching costs, a switching-cost model instead predicts the opposite relationship.

We interpret these findings as evidence that learning coherently explains the observed size dynamics, not as proof that it is the only or dominant underlying mechanism of

[4]This model yields an average spell length of 2.42, 2.49 spells per consumer, and a 37% switching probability, closely aligned with the benchmark moments.

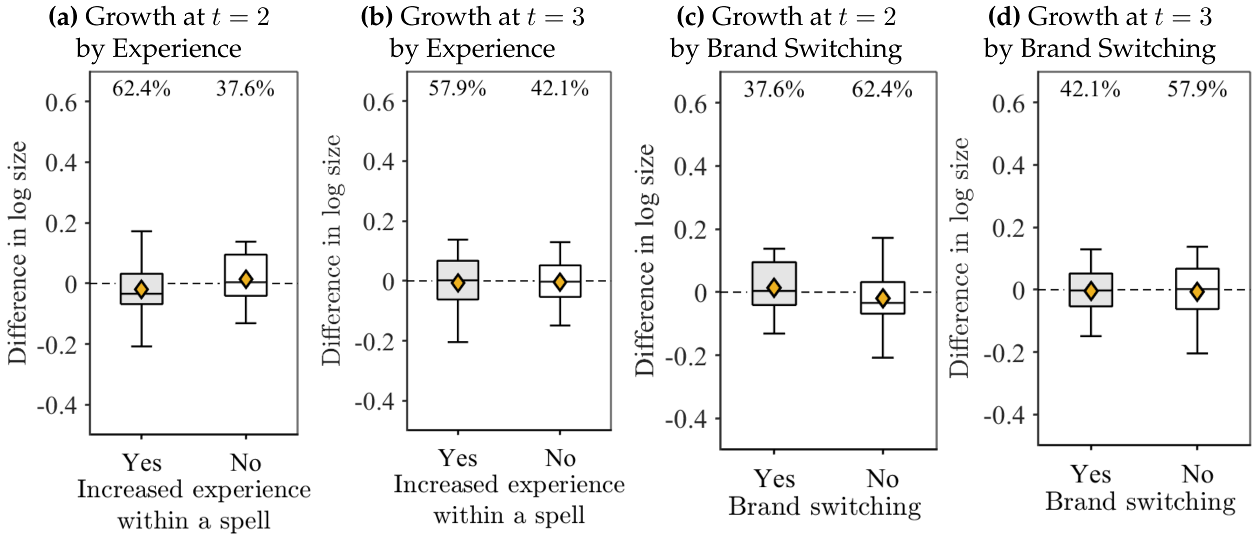

Figure 7: Counterfactual Exercise: Negligible Learning but Fixed Costs of Switching Brands

Notes: The figure reports simulated counterfactual outcomes with positive fixed costs of switching brands. Panels (a)–(d) correspond to the case with negligible quality uncertainty ($\sigma_q = 0.0001$) and switching cost $\chi = 0.035$. Panels (a) and (b) show the distribution of size growth by within-spell experience at the second and third trips, respectively; Panels (c) and (d) show the distribution by brand switching status. Each box represents the interquartile range with the median, yellow diamonds denote mean values, and gray dots indicate outside values.

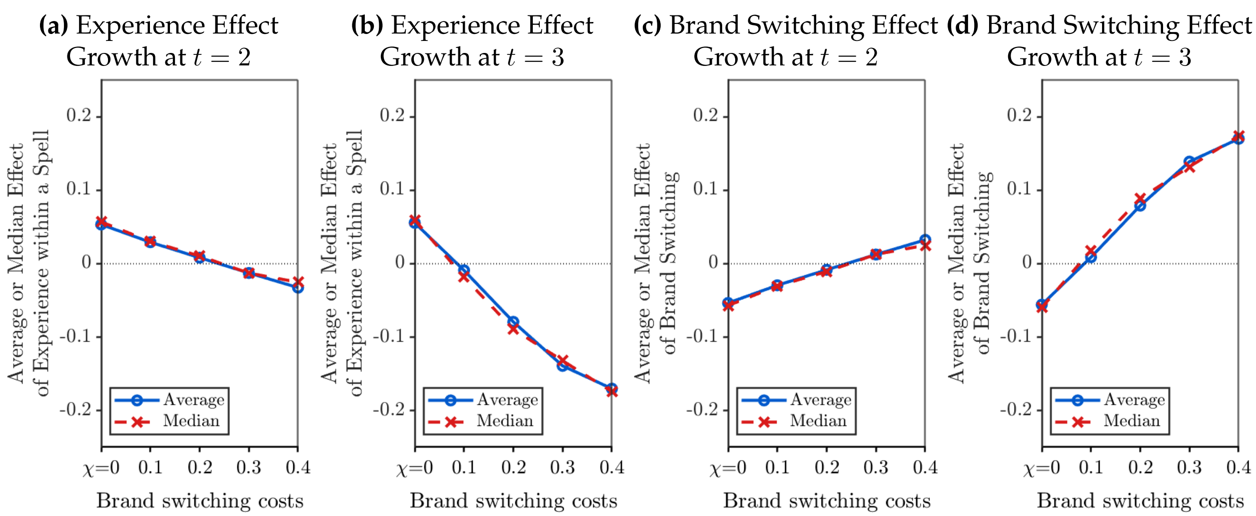

Figure 8: Counterfactual Exercise: Size Growth Differences over Fixed Costs of Switching Brands

Notes: The vertical axis, "Average Effect (blue)" or "Median Effect (red)", measures the difference in log size growth, plotted as a function of the fixed cost level of switching brands (χ). Panels (a) and (b) plot the experience effect: [Mean/Median Growth (Increased Experience = Yes) − Mean/Median Growth (Increased Experience = No)]. Panels (c) and (d) plot the switching effect: [Mean/Median Growth (Brand Switching = Yes) − Mean/Median Growth (Brand Switching = No)].

dynamic consumer behavior. The counterfactual results suggest the brand switching costs are unlikely to account for the observed purchase-size dynamics, although they may still contribute to state-dependent brand choice. Other mechanisms also remain possible. Exogenous habit information, for instance, could also generate within-spell size growth if repeated purchases increase consumers' willingness to buy larger package sizes.[5] Distinguishing learning from habit formation lies beyond the scope of this paper and a promising direction for future work. Our contribution is to highlight purchase size as a behavioral margin that responds systematically to experience and to show that a parsimonious learning model can rationalize its observed dynamics.

6. Concluding Remarks

In this paper, we bridge two central consumer decisions in packaged-goods markets: which brand to buy and how much to buy. We show that the evolution of purchase quantity with brand experience is informative about the mechanisms governing consumer behavior. Purchase quantity therefore deserves a more central role in the study of consumer packaged-goods markets.

Using scanner data from the U.S. cough-drop market, we document two robust patterns: purchase size increases with within-spell brand experience and decreases following brand switching. A model of learning about unobserved product quality reproduces these patterns, with consumers buying smaller sizes of less familiar brands. While the model explains behavior well when uncertainty is substantial, it is less suited to fully experienced consumers who are no longer learning. Once learning is complete, other mechanisms—such as satiation or variety-seeking—take over, as emphasized by Kim, Allenby and Rossi (2007), Hasegawa, Terui and Allenby (2012), and Bak (2019b). An important direction for future research is to integrate our framework of initial learning with these later-stage drivers. Combining the resolution of quality uncertainty with satiation dynamics could yield a richer life-cycle model of brand choice that explains both how loyalty is formed and why it eventually breaks down.

[5] One simple formulation is $s_{i,t} \sim \mathcal{N}(g(\mathsf{size}_{t-1})\mathbb{1}_{\{i_t=i_{i-1}\}} - 0.5\sigma_q^2, \sigma_q^2)$ where $g(\cdot)$ is an increasing function. In this specification, the growth purchase size in equation (15) depends directly on the previous purchase quantity within the spell through $\Delta \ln s_{i,t}$.

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A. Data and Regression Analysis

Table A.1: Internal Validity of Samples

	Original Data		Sample Used	
	Mean	(Median)	Mean	(Median)
Observations	356,686		127,581	
Total number of households	40,383		28,444	
Household income	19.82	(21)	19.64	(19)
Household size	2.44	(2)	2.26	(2)
Household composition	2.26	(1)	2.35	(1)
Age and presence of children	7.76	(9)	8.13	(9)
Male head age	5.56	(7)	5.87	(8)
Female head age	6.65	(8)	7.08	(8)
Male head employment	3.86	(3)	4.11	(3)
Female head employment	5.11	(3)	5.28	(3)
Male head education	3.08	(3)	3.04	(3)
Female head education	3.79	(4)	3.72	(4)
Male head occupation	6.41	(6)	7.12	(8)
Female head occupation	7.23	(8)	7.64	(12)
Marital Status	1.67	(1)	1.69	(1)
Race	1.30	(1)	1.30	(1)
Time elapsed from the previous purchase	173.18	(48)	373.46	(203)
Total number of purchases per household	8.83	(5)	14.33	(8)
For the households who went shopping at least 4 times				
Obs.	319,768		97,254	
No. of spells per household	2.51	(2)	3.22	(3)
Spell length for all spells	2.58	(1)	2.87	(2)
Fraction of brand switching (FBS) per household	0.40	(0.4)	0.26	(0.25)
Observations				
Halls	102,043		70,228	
Ricola	15,530		11,766	
Non-national Brands	65,329		45,587	
Market share for years 2011-2015 in each sample				
Halls	55.79%		54.84%	
Ricola	8.49%		10.24%	
Non-national Brands	35.72%		34.92%	

Table A.2: The List of Other Controls: Brand and Product Traits

Variable		Description
Price growth	Log_grow_p	Log of the percent change of price paid in the current shopping to the price paid in the previous shopping
Reference price	L_log_p_ref_p	Log of the ratio of price per unit to the weekly average price per unit in the US
Deals & discounts	deal01	Previous purchase was with no deal, but current purchase is with the deal (discounted price)
	deal10	Previous purchase was with deal, but current purchase is with no deal (discounted price)
	deal11	Previous purchase was with deal, but current purchase is with deal (discounted price)
	r_coupon	Discount rate (i.e., tag price – discounted price) / tag price
sugar-free related dummies		
	L_sugar_free	Indicator if the previous purchase was a sugar-free product.
	L_sugar_free_free	Indicator if both the product purchased in the previous shopping and the current shopping are sugar-free products.
Flavor related dummies: flavor x = herb, lemon, honey, menthol, cherry, fruit_etc, and eucalyptus		
	L_x	Indicator if the previous purchase was flavor x.
	L_x_x	Indicator if both the product purchased in the previous shopping and the current shopping are flavor x.
Flavor change	ch_flavor	Indicator if the flavor of the previous purchase is different from it of the current purchase.
Throat dummy	L_throat	Indicator if the function of the product purchased in the previous shopping is for the throat.
Time elapsed variables		
	ln_dis	Log of (the current shopping date minus the previous shopping date)
	t1_br2	It indicates the time elapsed from the first purchase of Halls.
	t1_br3	It indicates the time elapsed from the first purchase of Ricola.
Spell order dummies	i.spell4	Dummies for the order of spell, the first spell, the second spell, etc.
Previous brand choice dummies		
	Lag_br2	Indicator that the brand purchased in the previous shopping is Halls.
	Lag_br3	Indicator of the brand purchased in the current shopping is Ricola.
Total quantity the consumer has purchased of each brand		
	Log_lag_br2tq_n	Log of the total quantity of Halls the consumer has purchased
	Log_lag_br3tq_n	Log of the total quantity of Ricola consumer have purchased
Previous quantity choice dummies		
	L_tsize_n1	Total quantity of the previous purchase (1–24)
	L_tsize_n2	Total quantity of the previous purchase (25–39)
	L_tsize_n3	Total quantity of the previous purchase (40–99)
Purchase frequency dummies		
	Frq_type1	Customer had purchased cough-drop 0–1 times in a quarter
	Frq_type2	Customer had purchased cough-drop 2–3 times in a quarter
	Frq_type3	Customer had purchased cough-drop 4–9 times in a quarter
	Frq_type4	Customer had purchased cough-drop more than 9 times in a quarter
Household income dummies		
	d_income3	Customer annual income ($8,000–$9,999)
	d_income14	Customer annual income ($70,000–$99,999)
Store change	d_store	Indicator whether the place purchased cough-drop changed or not, compared to the place of previous purchase

Table A.3: Margarine Market: Regression Results of Size Growth and Brand Experience

	Dependent Variable: Size Growth			
	(1)	(2)	(3)	(4)
Number of previous purchases	0.0028^{***}			
	(0.0005)			
Log cumulative quantity		0.0340^{***}		
		(0.0012)		
Dummies for experience				
Brand switching			-0.0371^{***}	-0.0305^{***}
$\mathbb{1}(\text{experience} = 0)$			(0.0019)	(0.0019)
Medium experience				0.0190^{***}
$\mathbb{1}(3 \leq \text{experience} \leq 5)$				(0.0020)
High experience				0.0406^{***}
$\mathbb{1}(6 \leq \text{experience})$				(0.0030)
Growth rate of price paid	-0.3330^{***}	-0.3324^{***}	-0.3336^{***}	-0.3335^{***}
	(0.0034)	(0.0034)	(0.0034)	(0.0034)
$\ln(\text{date}_t - \text{date}_{t-1})$	-0.0135^{***}	-0.0124^{***}	$-{-0.0136^{***}}$	-0.0130^{***}
	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Other controls	✓	✓	✓	✓
Household FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Month FE	✓	✓	✓	✓
Observations	380,182	380,182	380,182	380,182
Number of Households	28,747	28,747	28,747	28,747
Within R-squared	0.5009	0.5024	0.5012	0.5015

Notes:*p<0.1, **p<0.05, ***p<0.01. Standard errors in parentheses are clustered within households. The omitted category is low experience ($\text{experience} \in \{1, 2\}$) in Column (4).

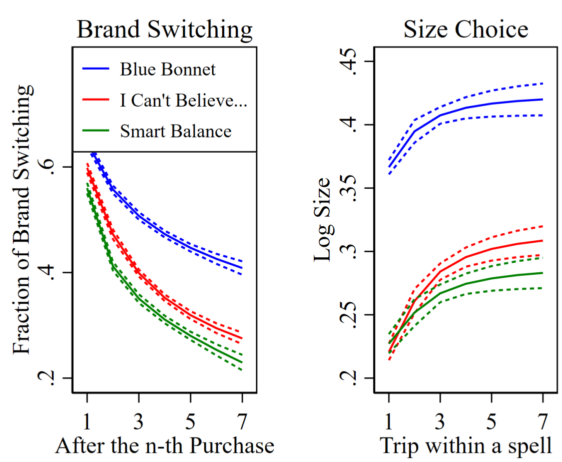

Figure A.1: Margarine Market: Fraction of Brand Switching and Size Choice over Experiences

Notes: The figure displays the fractional-polynomial prediction plots (solid lines) with the 95% confidence intervals (dashed lines). The first panel plots the fraction of brand switching for each brand; The second plots size choice (in log counts) for each brand.

B. Simulation Exercises

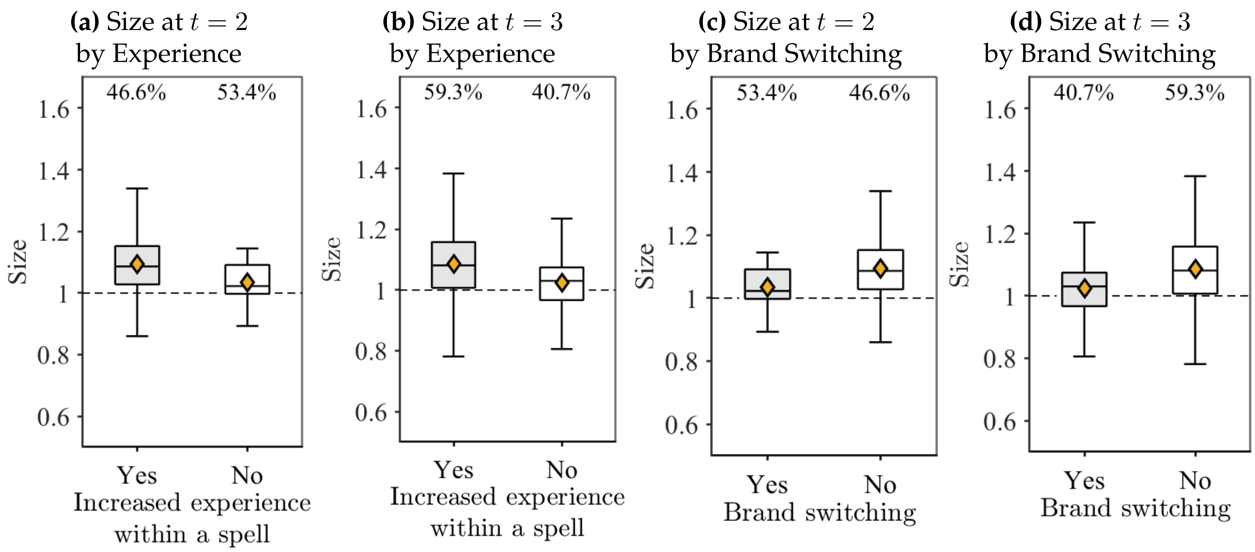

Figure A.2: Distribution of Size Choices with Experience and Brand Switching

Notes: Outside values are shown as gray dots. The figure reports the simulated first, second, and third quartiles and mean (yellow diamond) values of size choices with and without an increase in within-spell experience (Panels a and b) as well as with and without brand switching (Panels c and d).

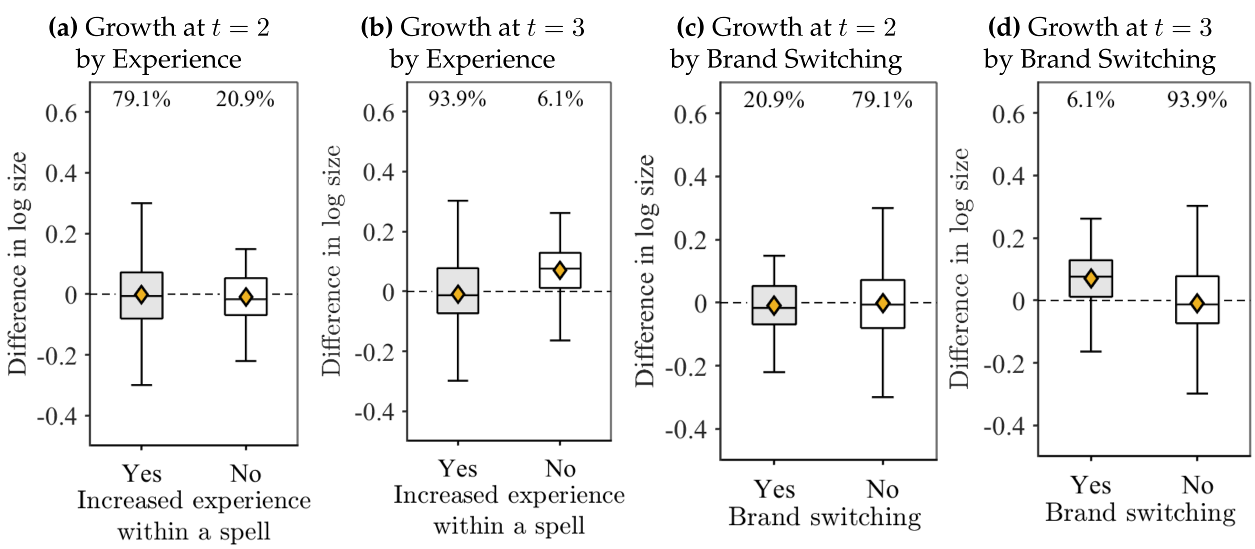

Figure A.3: Alternative Counterfactual: Distribution of Size Growth with Experience and Brand Switching

Notes: The figure reports simulated counterfactual outcomes with positive fixed costs of switching brands. Panels (a)–(d) correspond to the case with benchmark quality uncertainty ($\sigma_q = 0.1$) and higher switching cost $\chi = 0.2$. Panels (a) and (b) show the distribution of size growth by within-spell experience at the second and third trips, respectively; Panels (c) and (d) show the distribution by brand switching status. Each box represents the interquartile range with the median, yellow diamonds denote mean values, and gray dots indicate outside values.

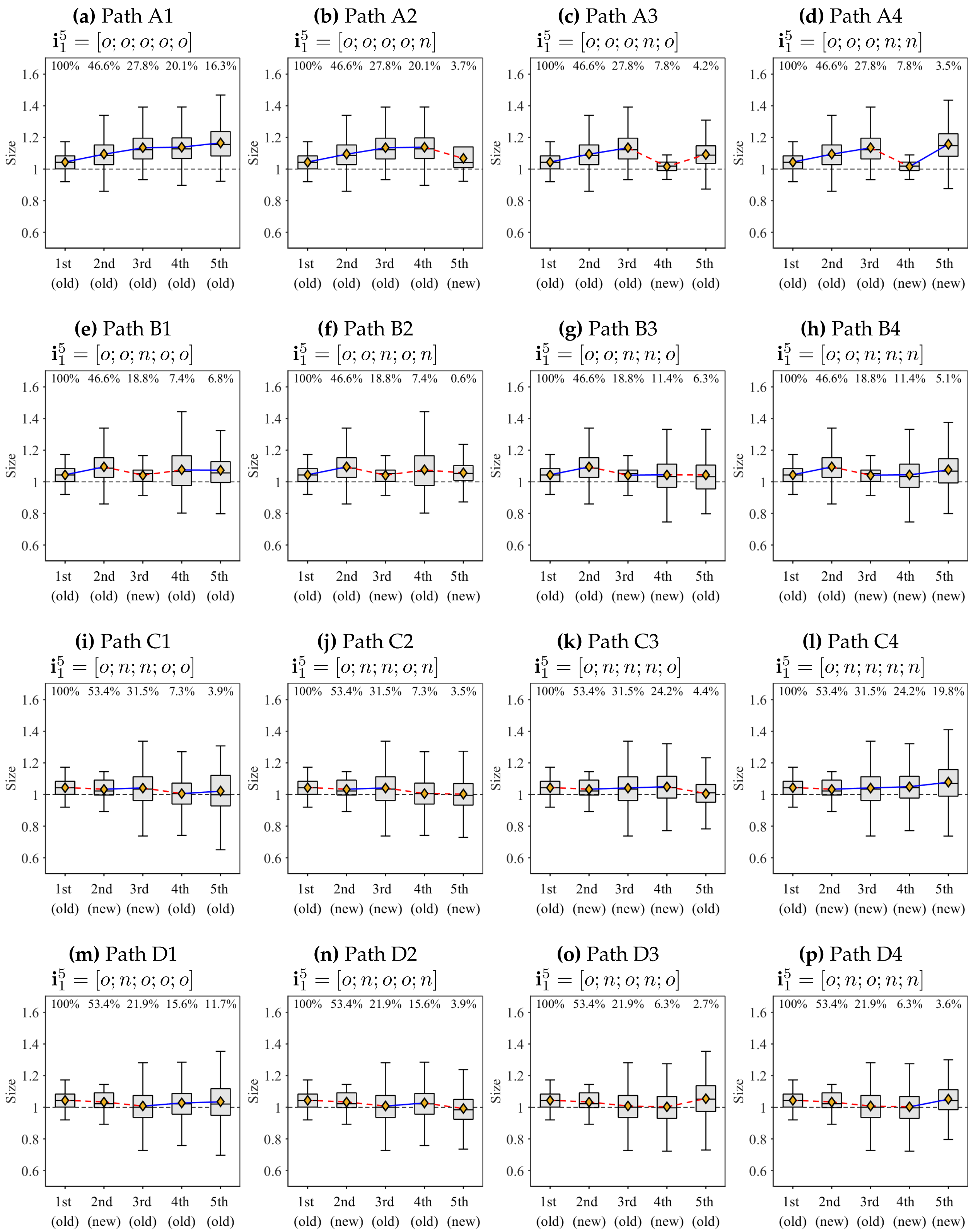

Figure A.4: Distribution of Size Choices by Brand Choice History ($t = 1, 2, 3, 4, 5$)

Notes: We plot the first, second, and third quartiles and mean (yellow diamond) values of sizes for each path. The dashed red lines indicate brand switching. Outside values are shown as gray dots.